Final Draft Economic Analysis for Oyster Restoration Alternatives

Douglas Lipton
Department of Agricultural & Resource Economics
University of Maryland College Park
College Park, MD 20742
dlipton@arec.umd.edu

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Alternative 1--No Action
Not taking the proposed action: Continue Maryland's present Oyster Restoration and Repletion Programs, and Virginia's Oyster Restoration Program under current program and resource management policies and available funding using the best available restoration strategies and stock assessment techniques.

Implementation Costs of Alternative 1

We use two approaches to estimate the costs of this alternative. First, since the alternative is based on actions in 2004, we use expenditure estimates from that period as one estimate. We follow that with an estimate that is based on a more detailed description of habitat rehabilitation and seeding costs.

The Maryland and Virginia oyster restoration programs are not static in either policy or available funding. Strategies have changed over time as information is gained on effective restoration techniques and for a variety of other reasons. Funding from state and federal sources also varies greatly from year to year. Table 1 shows how expenditures have varied from 1994-2006, both in their magnitude and use on harvest bars versus sanctuaries.

The reported state and federal expenditures for oyster restoration in 2004 totaled about $7.2 million dollars. It is assumed that these costs would be the same in each year of the ten-year time horizon chosen for analysis.

Table 1. Federal and state expenditures ($1,000 dollars, current) for oyster restoration by jurisdiction and placement on sanctuaries or harvest bars, 1994-2006.

	MD		**Potomac**		**VA**		**Combined**	
Year	**Harvest**	**Sanctuary**	**Harvest**	**Sanctuary**	**Harvest**	**Sanctuary**	**Harvest**	**Sanctuary**
1994	$795	$0	$94	$0	$408	$353	$1,297	$353
1995	$1,075	$0	$104	$0	$423	$245	$1,602	$245
1996	$1,427	$0	$102	$0	$278	$246	$1,807	$246
1997	$1,716	$0	$193	$0	$358	$416	$2,266	$416
1998	$2,016	$177	$191	$0	$276	$300	$2,483	$477
1999	$2,131	$187	$160	$0	$502	$390	$2,792	$577
2000	$2,312	$456	$253	$0	$766	$1,030	$3,331	$1,486
2001	$1,974	$270	$58	$0	$1,729	$665	$3,761	$935
2002	$3,051	$1,792	$30	$0	$3,257	$1,737	$6,338	$3,529
2003	$1,762	$1,665	$98	$0	$778	$475	$2,638	$2,140
2004	$3,775	$1,064	$12	$0	$494	$1,808	$4,282	$2,871
2005	$3,612	$1,532	$0	$0	$531	$705	$4,143	$2,236
2006	$4,863	$2,036	$0	$0	$830	$1,043	$5,694	$3,079

Source: Maryland Department of Natural Resources

To calculate the net present value equivalent of these expenditures, first the $7.2 million from 2004 is inflated to $7.9 million in 2007 dollars by applying the consumer price index available from the Bureau of Labor Statistics[1]. Next, we applied a real discount rate of 2.6% as specified by Office of Management and Budget[2] (OMB) for projects of 10 years to calculate the net present value of costs for the alternative. The net present value cost of implementing Alternative 1 based solely on reported state and federal expenditures is estimated at approximately $68.8 million.

This estimate is likely an underestimate of the total costs associated with the restoration activities since it reflects only the direct state and federal appropriations for oyster restoration. Extensive monitoring and management (Mon/Man) activities accompany these restoration efforts. Maryland DNR and PRFC estimated that these annual expenditures were $1.7 million, and $0.5 million, respectively. Since no estimate was available for Mon/Man for Virginia, we approximated these to constitute the same percentage of restoration outlays as they represent in Maryland and the Potomac, 30% of the restoration costs, or about $0.8 million. Additionally, the expenditure data does not include an estimate of the opportunity costs associated with full time state and federal employees or any percentage of agency overhead charges that should be allocated to the restoration effort. OMB Circular A-76 contains guidance on the calculation of full project costs and recommends that 12% of the activity costs be used to calculate the overhead.[3] Adding annual Mon/Man and overhead charges brings the full estimate of the net present value based on state and federal agency expenditures to $101.7 million.

A second and more detailed analysis of potential expenditures was conducted by obtaining yearly bar by bar estimates of habitat rehabilitation and seeding costs based on the scenarios provided for the demographic model (see Appendix XX). Per acre cost estimates for habitat restoration and per unit seed planting costs were obtained from Maryland DNR, VMRC and the PRFC. In this more detailed analysis we also included estimates of monitoring and management costs (Mon/Man) and overhead charges as was done above.

Annual expenditures for implementation of Alternative 1 vary over the 10 years, but on average are estimated to be around $12 million. The net present value of the ten years of expenditures at the 2.6% discount rate is $106.4 million (Table 2). While slightly exceeding our estimate based on adjusted agency expenditures, we use this estimate based on bar by bar rehabilitation because we can consistently use this approach to generate cost estimates for the other alternatives.

[1] http://www.bls.gov/cpi/home.htm
[2] http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html
[3] http://www.whitehouse.gov/OMB/circulars/a076/a76_rev2003.pdf

Table 2. Estimate of ten-year net present value (2.6% discount rate) of costs for implementation of Alternative 1 ($millions).

	Habitat	Seed	Mon/Man	Overhead	TOTAL
MD	$29.8	$17.3	$14.7	$7.4	$69.2
VA	$18.7	$4.3	$6.9	$3.6	$33.5
PRFC	$1.1	$2.2	$0.4	$0.4	$3.7
TOTAL	$49.6	$23.8	$22.0	$11.5	$106.4

Benefits of Alternative 1

Fishery Benefits

The harvest of oysters under this alternative is estimated from the oyster demographic model. The model can be run with a variety of assumptions about what the harvest rate of the population will be. The demographic modeling team determined that a 40% rate of removal of market size oysters would be used throughout the analysis to predict industry harvest levels. We use the data based on the 50th percentile results of the demographic model runs to estimate Maryland and Virginia landing for this alternative (Table 3).

Table 3 summarizes the net returns to harvesting oysters in Maryland and Virginia over the 10-year time horizon. Harvesting costs were based on the estimate by Wieland (2008) and is the mid-range of costs from that study. The Chesapeake (CB) price is based on the price flexibility from the inverse demand model detailed in Appendix D.

Table 3. Annual landings, Chesapeake Bay price, gross revenues, harvest costs and net revenues based on 40% harvest of market oysters under Alternative 1.

Year	MD Landings[1]	VA Landings[1]	CB Price	Gross Revenues	Harvest Cost	Net Revenue
1	1,003,164	1,174,494	$4.28	$9,327,729	$6,999,614	$2,328,115
2	856,245	1,218,969	$4.29	$8,907,455	$6,670,333	$2,237,122
3	494,865	1,437,212	$4.30	$8,317,167	$6,210,247	$2,106,920
4	330,762	1,364,029	$4.33	$7,330,752	$5,447,543	$1,883,210
5	301,496	909,549	$4.37	$5,289,389	$3,892,646	$1,396,742
6	281,463	839,156	$4.38	$4,903,270	$3,601,988	$1,301,282
7	266,411	610,999	$4.40	$3,857,709	$2,820,247	$1,037,462
8	265,895	360,713	$4.42	$2,768,706	$2,014,099	$754,607
9	278,871	241,470	$4.43	$2,303,977	$1,672,525	$631,452
10	295,114	179,861	$4.43	$2,104,982	$1,526,705	$578,276

[1]Pounds of meats, approximately 7 pounds per bushel (Muth et al. 2000).

The net present value of this stream of net revenues using the 2.6% rate of discount is $12.8 million. Based on Wieland's (2008) break-even cost analysis and assumption of a full fishing season of 100 days, this harvest would support an average of 20-42 full-time watermen equivalents over the ten year period. The actual number of watermen continuing to harvest will be greater than that depending on the fraction of the 100 day season watermen choose to fish.

Processor Benefits/Consumer Benefits

According to Murray (2002), virtually all of Virginia's processed oyster production is from oysters harvested from other states, principally the Gulf of Mexico. The same is true of Maryland-based oyster processors. Under this alternative, it is expected that Chesapeake processors will continue to rely on shellstock from other regions to supply regional markets. These processors and retail markets will supplement this imported shellstock with the continued low level of harvests from Chesapeake Bay waters.

We do not have comprehensive cost and returns data on oyster processing to generate estimates of profits to this segment of the industry, and particularly a differential in profits from oysters produced locally versus shellstock transported in from other producing regions. In Lipton et al. (2006) we generated estimates of the wholesale value of oysters based on assumptions regarding the percentage of oysters sold as halfshell (30%) out of the available shellstock. Starting with a wholesale price of $0.20 for halfshell oysters and $48 for a gallon of shucked oysters, we calculated the gross revenues for the wholesale value of the Chesapeake Bay harvest over the ten-year time horizon. For the ten year time horizon, wholesale prices were allowed to fluctuate in direct proportion to harvest prices derived from the inverse demand model. We also subtracted out the predicted harvest cost since we know this is what the processor or wholesaler will have to pay for these oysters. Table 4 gives the annual gross wholesale value and the value net of harvest cost for the wholesale industry. The estimate of the present value of revenues net of harvesting costs at the wholesale level for Maryland harvested oysters under Alternative 1 is $35.8 million. While these revenue estimates cannot be interpreted as a benefit, this figure is helpful for comparison with revenue estimates from the other alternatives.

Table 4. Estimated wholesale value and revenue net of oyster cost for projected oyster harvest from Chesapeake Bay

Year	Gross Revenue	Oyster Cost	Revenue Net of Oyster Cost
1	$16,052,448	$9,327,729	$6,724,719
2	$15,329,183	$8,907,455	$6,421,728
3	$14,313,334	$8,317,167	$5,996,166
4	$12,615,775	$7,330,752	$5,285,022
5	$9,102,713	$5,289,389	$3,813,324
6	$8,438,226	$4,903,270	$3,534,956
7	$6,638,880	$3,857,709	$2,781,171
8	$4,764,773	$2,768,706	$1,996,067
9	$3,965,003	$2,303,977	$1,661,026
10	$3,622,544	$2,104,982	$1,517,562

Indirect Benefits

Lipton et al. (2006) discuss the indirect economic benefits associated with the oyster resource, particularly the economic value of ecological services. Some of the ecological services provided by oysters that may provide economic benefit include improved water quality and habitat functions leading to:

- Larger populations of, and potentially greater industry profits and consumer benefits from other important commercial species in Chesapeake Bay such as striped bass and blue crab

- Larger populations and potentially greater economic benefits from important Chesapeake Bay recreational species

- Improved water clarity leading to higher values for other forms of Chesapeake Bay recreation such as swimming and boating, and higher values for waterfront profit

Calculation of the economic benefits related to ecological services from oyster populations would require quantification of the ecological changes related to oyster populations. These quantifications have not been estimated for the alternatives, and thus, it is not possible to estimate the indirect economic benefits for each alternative. The Ecological Risk Assessment (ERA, see Appendix Y) uses a relative risk model (RRM) to assesses the relative positive and negative influences associated with changes in habitat, food, and water quality. This information affords insights into possible increases or decreases in ecological services including the potential for improvement in the Bay's water quality. However, the RRM does not predict the actual magnitudes of changes or risks such as the increase or decrease in abundance. Thus, the ERA can be used only as a general guide to the direction of change in potential indirect economic benefits from one alternative compared to another. Even then, caution must be taken in interpreting positive ecological interactions as indicators as positive economic benefits. In a complex ecosystem such as Chesapeake Bay what appears to be a positive ecological interaction between oyster abundance and other organisms can result in negative economic consequences.

The RRM for this alternative shows declining scores for all but the Maryland oligohaline region of Chesapeake Bay. Since these declines are occurring from an already significantly reduced ecological impact of oysters in the Bay, it is unlikely that this alternative will lead to additional declines in indirect economic value from the resource. It is also not anticipated that the increase in oyster biomass in the Maryland oligohaline will be significant enough to result in indirect economic benefit in this section of the Bay.

Alternative 2--Expand native Oyster Restoration Program

Expand, improve, and accelerate Maryland's Oyster Restoration and Repletion Programs, and Virginia's Oyster Restoration Program in collaboration with Federal and private partners. This work would include, but not be limited to an assessment of cultch limitations and long-term solutions for this problem and the development, production, and deployment of large quantities of disease resistant strain(s) of C. Virginia (Eastern Oyster) for brood stock enhancement.

Costs of Alternative 2

Implementation of Alternative 2 requires a major increase in investment in the habitat rehabilitation and seeding program as outlined in [insert section]. The same cost factors for habitat and seed as were used to determine the detailed cost estimates for Alternative 1 are used to determine the detailed cost for Alternative 2. Implicitly this assumes that the analysis fails to capture any economies of scale that might accrue to this expanded effort. Conversely, we feel that monitoring and management costs will not increase in proportion to the overall habitat and seeding program, although we do believe they will increase. To represent the increase we estimate monitoring and management cost to be equal to those costs under Alternative 1 plus 10% of the incremental habitat and seed costs for Alternative 2.

Table 5. Estimate of ten-year net present value (2.6% discount rate) of costs for implementation of Alternative 2 ($millions).

	Habitat	Seed	Mon/Man	Overhead	TOTAL
MD	$96.8	$102.3	$29.9	$27.5	$256.5
VA	$90.5	$15.0	$15.2	$14.5	$135.1
PRFC	$2.0	$8.1	$1.1	$1.1	$12.5
TOTAL	$189.3	$125.4	$46.1	$43.3	$404.1

Benefits of Alternative 2

Fishery Benefits

The amount of oysters harvested under this alternative was based on results of the oyster demographic model (Table 6). Over the ten year period, oyster harvests increase by 69% compared to the no action alternative.

Table 6. Annual landings, Chesapeake Bay price, gross revenues, harvest costs and net revenues based on 40% harvest of market oysters under Alternative 2.

Year	MD Landings	VA Landings	CB Price	Gross Revenues	Harvest Cost	Net Revenue
1	1,003,164	1,174,494	$4.28	$9,327,729	$6,999,614	$2,328,115
2	856,750	1,222,990	$4.29	$8,926,063	$6,684,882	$2,241,181
3	495,587	1,471,666	$4.30	$8,462,561	$6,323,313	$2,139,248
4	396,463	1,387,207	$4.32	$7,701,380	$5,733,226	$1,968,154
5	555,747	925,579	$4.34	$6,434,979	$4,761,407	$1,673,573
6	732,897	834,952	$4.34	$6,799,014	$5,039,513	$1,759,501
7	995,410	594,351	$4.33	$6,891,000	$5,109,945	$1,781,055
8	1,442,841	365,357	$4.32	$7,803,418	$5,812,065	$1,991,353
9	2,477,660	255,357	$4.23	$11,574,258	$8,784,697	$2,789,561
10	4,113,489	196,947	$4.10	$17,661,994	$13,854,975	$3,807,019

The net present value of the increased oyster harvest under this alternative is $19.4 million, a 51% increase over Alternative 1. The increased harvestable population in this scenario can support from 33-71 full-time equivalent watermen. In contrast to Alternative 1, the number of watermen supported increases over the ten years. Near the end of the period, the significant increases in Maryland more than offset the industry decline in Virginia.

Processor Benefits/Consumer Benefits

We assume the same ratio of halfshell to shucked oysters in the wholesale marketplace as Alternative 1. We also assume that wholesale prices move in proportion to estimated harvest prices. The present value of wholesale revenues increases over alternative 1 by 58% to $56.8 million under Alternative 2. This represents an increase in revenues associated with locally caught oysters, but again, not necessarily a net increase in overall processed oyster production if it is simply replacing imported shellstock. However, if there are higher processor profits with locally produced oysters compared with imported shellstock, the increase in revenue net of harvest cost could serve as an indicator of processor benefits. Similarly, if consumers prefer local oysters to those produced from imported shellstock they will benefit in similar proportion.

Table 7. Estimated wholesale value for projected oyster harvest from Chesapeake Bay for Alternative 2.

Year	Gross Revenue	Oyster Cost	Revenue Net of Oyster Cost
1	$16,052,448	$9,327,729	$6,724,719
2	$15,361,205	$8,926,063	$6,435,143
3	$14,563,548	$8,462,561	$6,100,987
4	$13,253,601	$7,701,380	$5,552,222
5	$11,074,204	$6,434,979	$4,639,225
6	$11,700,686	$6,799,014	$4,901,672
7	$11,858,987	$6,891,000	$4,967,987
8	$13,429,202	$7,803,418	$5,625,785
9	$19,918,586	$11,574,258	$8,344,328
10	$30,395,206	$17,661,994	$12,733,212

Indirect Benefit

The overall RRM scores for this alternative are significantly higher in the Maryland oligohaline compared with Alternative 1, and positive in other areas except Virginia polyhaline. Because this alternative entails significantly more habitat rehabilitation than Alternative 1, it has significantly higher positive RRM for hard bottom habitat and reef associated fish. As discussed in Lipton et al. (2006) and analyzed in Hicks et al. (2004), recreational anglers show a preference for fishing on hard bottom habitat and would have a positive economic benefit even if the oyster habitat did not lead to larger populations of recreational fish. In their analysis, a specific set of restoration projects adding to 1,890 restored acres of oyster bottom had an annual benefit to recreational anglers of $720,000 (in 2007 dollars), or a net present value of $6.3 million over 10 years. Since their analysis is dependent on the location of the restoration projects relative to fishing activity in Chesapeake Bay, the specific location of habitat restoration in Alternative 2 will provide different results; however, this does serve as a relative indicator of indirect benefits in the form of recreational fishing resulting from oyster habitat restoration.

Comparison of Alternatives 2a and 2b
As described in section{?}, Alternative 2 has two scenarios that differ based on the strategy of seeding in the sanctuary areas. The analysis above is based on the planting strategy for Alternative 2a. While a similar analysis was conducted for Alternative 2b, the difference in restoration costs between the two scenarios was extremely small. Fishery benefits also did not differ significantly between the two scenarios. Given the large uncertainties in economic data, these two alternatives are virtually indistinguishable from an economic perspective.

Alternative 3--Harvest Moratorium
Implement a temporary harvest moratorium on native oysters and an oyster industry compensation (buy-out) program in Maryland and Virginia or a program under which displaced oystermen are offered on-water work in a restoration program.

Costs of Alternative 3

For harvesters, foregone net income is a measure of the cost of imposing the moratorium. The foregone net income depends on which restoration scenario the moratorium is imposed upon. Under Alternative 1, the foregone net present value of net income is $12.8 million, but rises to $19.4 million under Alternative 2. A buy-out program that compensates watermen for foregone net income does not impact the estimate of costs; it simply shifts the costs of the moratorium from the watermen to the public sector. Hiring displaced watermen preferentially to conduct on-water restoration is also simply an income transfer from non-displaced watermen or other individuals and firms to displaced watermen.

Benefits of Alternative 3

Fishery Benefits
Since this alternative specifies the moratorium as temporary, benefits to the fishery can accrue once the moratorium has been lifted. The benefits would then be calculated as the increased profits to oystermen compared with Alternative 1. The increase in profits would be related to an increase in oyster biomass that would lower the cost because of an increase in individual fisherman catch per unit of effort. Given the small increase in oyster biomass predicted by the demographic model for the oyster moratorium and the need to discount the benefits that start to accrue in the years the fishery reopens to calculate their present value, it is unlikely that this alternative would result in significant positive net benefits to the fishery. To demonstrate, this we compared the demographic model estimate of market size oyster biomass in year 10 under this alternative compared with Alternative 1. Based on this analysis, if the fishery was opened in year 10, the increase in year 10 net revenues compared to Alternative 1 would be $175 thousand or $135 thousand in present value. The harvest industry would have foregone $12.8 million in present value net revenues to have obtained that increase when the fishery was opened. It would require running the demographic model beyond the ten year time horizon to

calculate further discounted increases in industry net revenues, but since fishing mortality will begin to accrue again, the small net income differential will dissipate.

Processor Benefits/Consumer Benefits

As was stated earlier, the bulk of oysters processed and sold in the region are already being provided by other producing areas. Therefore, it is anticipated that the total elimination of Chesapeake sourced harvest will have a relatively small impact on the small number of remaining processors in the region. A moratorium could have a larger impact on processors than anticipated if part of the decision to continue in business is an anticipation of increased harvests of Chesapeake Bay oysters in the near future. If processors view the moratorium as a long term closure of the fishery, that might alter business decisions based on near-term potential harvests.

Oyster consumers already have limited availability of Chesapeake Bay oysters. A harvest moratorium would have the greatest impact on consumers that specifically seek and prefer Chesapeake Bay oysters for purchase.

Indirect Benefit

According to the RRM, this alternative performs slightly better than Alternative 1 depending on the salinity zone, basically following the predicted oyster biomass. Thus, it is anticipated that this option will have indirect economic benefits similar to Alternative 1.

Alternative 4--Aquaculture:

Establish and/or expand State-assisted, managed or regulated aquaculture operations in Maryland and Virginia using the native oyster species.

Costs of Alternative 4

Private aquaculture of *C. virginica* exists in Chesapeake Bay, but is limited. Entrepreneurs are experimenting with a variety of off-bottom and on-bottom practices. Interest has arisen in production of triploid *C. virginica*. The analysis of Chesapeake Bay oyster aquaculture in Appendix X demonstrates that a variety of aquaculture alternatives are economically viable with the native oyster species at current high prices. Significant expansion of production from aquaculture will lead to lower prices, making the operations more risky and limiting the overall size of the industry. To determine the additional public costs of this alternative will require specifying what actions the states will undertake to expand aquaculture beyond what the market will allow. Some actions may have little or no public cost such as relaxing or streamlining regulatory constraints. Other actions such as direct subsidies, subsidization of seed production, low or no interest loans, can have substantial public costs associated with them.

Other than any subsidized costs mentioned above, expanded aquaculture will entail the private costs of oyster producers. As discussed in Appendix X, these costs will be borne if the price of oysters is sufficiently high enough to cover them and provide a return on investment and management. Any benefits discussed below are net of these estimated private costs.

Benefits of Alternative 4

Fishery Benefits

Under this alternative, it is assumed that the wild fishery will continue as in Alternative 1. Aquaculture will supplement this local production of oysters from Chesapeake Bay. Based on the analysis in Appendix X, we believe there is the potential for a private aquaculture industry based on *C. virginica* production of about 330,000 bushels per year sold at about $0.19 per oyster. This level of aggregate production would support approximately 94 “representative size” aquaculture firms producing about 3,500 bushels each of *C. virginica* for the halfshell market. The Monte Carlo simulations used to simulate this operation show a great deal of uncertainty in economic performance. Over the ten years that the simulations are run, the total net present value of the individual firm is about $190,000, but the coefficient of variation of the net present value from the model runs is 42%. Note that the ten years that the model runs is not the same ten year time period of study of the EIS. These 94 firms would not appear overnight, but would gradually increase as industry support capacity such as hatchery production increases. Our analysis predicts the market equilibrium number of firms, but not the path in terms of how many firms will develop over ten years to achieve that equilibrium.

To make comparisons to the other alternatives, we assume that in the first year there are 10 firms corresponding to the participants in the Virginia Seafood Council trials. The number of firms is assumed to increase by 10 firms a year and 4 firms in the tenth year to achieve the predicted equilibrium of 94 firms by year 10 of the planning horizon. We then compute the net present value of the industry for the ten year time horizon corresponding to the period of analysis for the EIS. Thus, the first 10 firms are credited with $190,000 each and contribute $1.9 million. The firms that enter in the second year only contribute $179,000 each, with each subsequent’s year contributing less (Table 8). The net present values were calculated by running the Monte Carlo simulations for the shorter number of years. Since the software used requires a minimum of a five year time horizon, the net present value for firms in business 4 years or less was determined by examining the performance on the firms in business longer. First, the net present value was determined to be zero for firms in business 2 years or less. Net present value for four year firms was 50% of five year firms, and for three year firms it was 25% of five year firms. The minimum and maximum values in Table 8 correspond to the range of 1 standard deviation from the predicted value. Under this scenario, it is predicted that an expanded C. virginica aquaculture industry will contribute about $8 million in net present value, but the amount could range from $6-$15 million.

Table 8. A scenario of *Crassostrea virginica* industry growth and estimated net present value for the ten year planning horizon.

Year	New Firms	Firm NPV	Industry NPV	Min	Max
1	10	$190,000	$1,900,000	$ 1,102,000	$ 2,698,000
2	10	$179,000	$1,790,000	$ 1,038,200	$ 2,541,800
3	10	$167,000	$1,670,000	$ 968,600	$ 2,371,400
4	10	$163,000	$1,630,000	$ 945,400	$ 2,314,600
5	10	$133,000	$1,330,000	$ 771,400	$ 1,888,600
6	10	$116,000	$1,160,000	$ 672,800	$ 1,647,200
7	10	$58,000	$580,000	$ 336,400	$ 823,600
8	10	$29,000	$290,000	$ 168,200	$ 411,800
9	10	$0	$0	$ -	$ -
10	4	$0	$0	$ -	**$ -**
TOTAL	94		$10,350,000	$ 6,003,000	$ 14,697,000

The aquaculture production discussed above is based on fairly intensive aquaculture production because that is where most of the data has been collected. The potential exists for a viable extensive *C. virginica* production industry based on triploid or fast-growing strains of oysters. As this technology develops, it has the potential to supplement or compete with intensive aquaculture, and if the production costs can be reduced enough through high survival and economies of scale, become a viable source of product to compete for the lower-priced shucked oyster market. Data to further analyze extensive aquaculture production was not available at the time of the writing of this EIS.

Indirect Benefits

The relative risk model shows that given the scale of oyster aquaculture anticipated in Chesapeake Bay there may be very limited ecological effects. Thus, we do not expect any significant indirect effects arising from this aquaculture alternative.

Alternative 5-- Aquaculture:

Establish State-assisted managed or regulated aquaculture operations in Maryland and Virginia using suitable triploid, nonnative oyster species.

Costs of Alternative 5

As in Alternative 4, the level and nature of state assistance will determine the public costs of this alternative. The private costs are included in the discussion of net economic benefits to the industry.

Benefits of Alternative 5

Fishery Benefits

Under this alternative, it is assumed that the wild fishery will continue as in Alternative 1. Aquaculture will supplement this local production of oysters from Chesapeake Bay. Based on the analysis in Appendix D, we believe there is the potential for a private aquaculture industry based on *C. ariakensis* of 780,000 bushels supplied by about 223 of our "representative size"aquaculture firms producing about 3,500 bushels sold at about $0.16 per oyster. Over the ten years that the simulations are run, the total net present value of the individual firm is about $122,000, less than in Alternative 4. The coefficient of variation of the net present value from the model runs is 69%. The larger industry and aggregate production compared to Alternative 4 lowers the net benefit per firm and increases the variability of that benefit in Alternative 5 In general, more producers are made better off in Alternative 5 compared with Alternative 4, but the individual producer in Alternative 4 is better off than an equivalent producer in Alternative 5.

A net present value for the full industry over the 10 year time horizon of the EIS was estimated in a manner similar to Alternative 4. We started with 10 firms and built to 223firms by adding 30 firms a year in years 2-5, 20 firms in years 6-9 and 10 firms in year 10. Firms in year 1 contribute $126,000 each to the net present value, with later firms contributing less (Table 9). The overall industry net present value is $15 million with a one standard deviation range of $9 - $23 million. Thus, the aquaculture industry based on *C. ariakensis* will have a greater expected economic benefit than the one based on *C. virignica*. The *C. ariakensis* based industry will support more firms, and thus create more employment opportunities for watermen and others.

Table 9. A scenario of *Crassostrea virginica* industry growth and estimated net present value for the ten year planning horizon.

Year	New Firms	Firm NPV	Industry NPV	Min	Max
1	10	$126,000	$1,260,000	$ 730,800	$ 1,789,200
2	30	$123,000	$3,690,000	$ 2,140,200	$ 5,239,800
3	30	$112,000	$3,360,000	$ 1,948,800	$ 4,771,200
4	30	$107,000	$3,210,000	$ 1,861,800	$ 4,558,200
5	30	$79,000	$2,370,000	$ 1,374,600	$ 3,365,400
6	20	$61,000	$1,220,000	$ 707,600	$ 1,732,400
7	20	$36,000	$720,000	$ 417,600	$ 1,022,400
8	20	$18,000	$360,000	$ 208,800	$ 511,200
9	20	$0	$0	$ -	$ -
10	13	$0	$0	$ -	$ -
TOTAL	223		$16,190,000	$ 9,390,200	$ 22,989,800

One has to note, however, the large uncertainty in the range of outcomes. Similar caveats and uncertainties from Alternative 4 apply to Alternative 5 as well. Based on recent experience with *C. ariakensis*, it may be used more as a shucked oyster, maintaining a higher price compared to *C. virginica* in that market due to significantly higher shucking yields. What is unknown is how a much larger scale shucked production of *C. ariakensis* produced in higher cost intensive systems can compete with also high yielding *C. gigas* that is mainly produced in lower cost extensive production systems. *C.ariakensis* produced in a more extensive aquaculture operations should have signficantly lower production costs than intensive operations, and thus, be more competitive with shucked *C. gigas* that is imported to the region from the west coast. Due to the restricted nature of the Virginia Seafood Council trials, no data on production costs for *C. ariakensis* in Chesapeake Bay is available for analysis.

Indirect Benefits

Although this alternative anticipates a slightly larger scale oyster aquaculture industry in Chesapeake Bay compared with Alternative 4, the relative risk model still shows very limited ecological effects. Thus, we do not expect any significant indirect effects arising from this aquaculture alternative.

Alternative 6—Introduce and Propagate an Alternative Oyster Species (Other than *C.ariakensis*) or an Alternative Strain of *C. ariakensis*

Introduce and propagate in the State sponsored, managed or regulated oyster restoration programs in Maryland and Virginia, a disease resistant oyster species other than C. ariakensis, or an alternative strain of C. ariakensis, from waters outside the U.S. in accordance with the ICES 1994 Code of Practices on the Introductions and Transfers of Marine Organisms.

No economic analysis was conducted regarding this alternative.

Alternative 7 -- Introduction of Diploid *Crassostrea ariakensis* And Discontinuation of *Crassostrea virginica* Restoration Programs:

Introduce the oyster species, *Crassostrea ariakensis*, into the tidal waters of Maryland and Virginia for the purpose of establishing a naturalized, reproducing, and self-sustaining population of this oyster species. Diploid *C. ariakensis* would be propagated from existing 3rd or later generation of the Oregon stock of this species, in accordance with the International Council for the Exploration of the Sea's (ICES) 2003 Code of Practices on the Introductions and Transfers of Marine Organisms. Deployment of diploid *C. ariakensis* from hatcheries is proposed to occur first on State designated sanctuaries, where harvesting would be prohibited permanently, and then on harvest reserve and special management areas where only selective harvesting would be allowed.

Costs of Alternative 7

Using the same approach as for Alternatives 1 and 2, we calculate the habitat restoration, seeding, monitoring, management and overhead costs for planting C. ariakensis seed over the 10 year period.

Table 10. Estimate of ten-year net present value (2.6% discount rate) of costs for implementation of Alternative 7 ($millions).

	Habitat	Seed	Mon/Man	Overhead	TOTAL
MD	$29.8	$93.0	$22.3	$17.4	$162.5
VA	$53.3	$15.0	$11.4	$9.6	$89.3
PRFC	$3.1	$2.2	$0.6	$0.7	$6.6
TOTAL	$86.2	$110.2	$34.3	$27.7	$258.4

Harvest Benefits of Alternative 7

The harvest benefits from this alternative cannot be quantified without the quantitative estimates from the oyster demographic model. However the model can be used to simulate an expected harvest for an oyster that has a growth, reproductive and mortality rate as specified. Using the 40% harvest rate to be consistent with comparison to the other alternatives, this simulated oyster would result in a ten-year harvest that is about 40% higher than Alternative 1 and 8% higher compared with Alternative 2. The difference between the alternatives is limited by the fact that there would be no harvest due to the priority creation of sanctuaries in Alternative 7 during the first two years, while harvest occurs in those years for Alternatives 1 and 2. Since all the simulations were run for an additional year, it is interesting to compare the projected harvests in year 11. For Alternative 1, year 11 harvests fall to less than 500,000 pounds, but rise to about 5.7 million pounds in Alternative 2. In contrast, the simulated harvests in Alternative 7 would exceed the estimated maximum economically sustainable harvest for Chesapeake Bay.

For illustrative purposes, we used the same methodology to calculate the net present value of the simulated oyster harvest as in the other alternatives. Price was adjusted with harvest to reflect own price flexibility which resulted in a significant lowering of net present value with the assumed higher harvest. Because oysters would be denser in this alternative, we lowered the harvest cost from $0.075 per oyster, the mid-range of the Wieland (2006) estimate to $0.05, the lower value of the range. The net present value for the ten-year period for oyster harvest net revenues under these assumptions is $45.1 million. What happens beyond the ten-year planning horizon would be critical to determining the commercial net benefits of this alternative. For example, if harvests can be sustained at the maximum economically feasible level with little or no additional implementation costs, a longer time horizon for analysis might yield positive net benefits. This would also depend on adopting a management regime for oyster harvests that prevents economic overfishing and the dissipation of positive net revenues.

Processor benefits were also calculated in the same manner as the other alternatives. Net present value of processor revenue net of the cost of oysters to the processor was $94.9 million.

Indirect Benefits

See discussion for the Proposed Action

Proposed Action

Costs of Proposed Alternative

The implementation cost for the Proposed Alternative is not simply the addition of Alternative 1 and Alternative 7. Areas for habitat rehabilitation are limited as are the areas to receive seed. Hatchery capacity is also a limiting factor. Thus, the total cost of implementing the Proposed Alternative differs in the net present value compared with Alternative 7 by only an additional $5.8 million (Table 7).

Table 11. Estimate of ten-year net present value (2.6% discount rate) of costs for implementation of the Proposed Alternative ($millions).

	Habitat	Seed	Mon/Man	Overhead	TOTAL
MD	$29.9	$110.8	$9.4	$18.0	$168.0
VA	$53.5	$19.2	$5.0	$9.3	$87.0
PRFC	$3.1	$4.6	$0.4	$1.0	$9.1
TOTAL	$86.5	$134.6	$14.8	$28.3	$264.2

Benefits of Proposed Alternative

Fishery Benefits

As in the analysis of Alternative 7, we are limited in estimating the fishery benefits by the limitations of the demographic modeling in regard to *C. ariakensis* populations. For comparison purposes, and using the same assumptions for calculation of fishing benefits, we calculated a potential net present value of fishing over the ten year time frame for the Proposed Action. We used a fishing cost of $0.075 per oyster for the first two years of the analysis since only *C. virginica* would be harvested in those years. For years 3-10, the fishing cost was lowered to $0.05 per oyster to be consistent with the analysis of Alternative 7. The net present value of fishing benefits increases to $56.4 million for the Proposed Action if the introduced oyster performs as anticipated. Net present value of processor revenues net of oyster costs was $127.6 million for this alternative. Continued production of native oysters during the first two years account for most of the difference between this alternative and alternative 7.

Indirect Benefits

As discussed in Alternative 2, the most likely indirect benefit to be impacted by oyster restoration is recreational fishing over hard bottom reefs. For this alternative, the relative risk model predicts significant beneficial interactions with hard bottom habitat in all the salinity regimes in the Bay where restoration activities will occur. Similarly, reef associated fish will benefit. Together, these indicate that the Proposed Action may lead to benefits for recreational fishermen throughout Chesapeake Bay. These benefits would be due to greater availability of preferred fishing grounds and potentially higher catch rates due to the aggregating function of fish reefs or higher levels of fish populations. According to Marine Recreational Fishery Statistics Survey data[4], over 6 million recreational fishing trips were taken in Chesapeake Bay in 2006. Improved recreational fishing due to restored hard bottom oyster reefs could increase the average value of those fishing trips, although we do not attempt to quantify this.

[4] http://www.st.nmfs.noaa.gov/st1/recreational/queries/effort/effort_time_series.html

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